

Remarks:

New claim 26 has been amended. Claims 13-22 were previously cancelled. Accordingly, claims 1-12 and 23-26 are currently pending for consideration.

I. Amendments:

New independent claim 26 is directed to a process for producing alkali metal chlorate. Support for this claim can be found in claims 1, 2, 4, 5, 6 and 24, and in the specification at page 3, lines 9-12. No new matter has been added.

II. The Invention:

The presently claimed invention is directed to a process for producing alkali metal chlorate in an electrolytic cell that is divided by a cation selective separator into an anode compartment in which an anode is arranged and a cathode compartment in which a gas diffusion electrode is arranged. The process comprises introducing an electrolyte solution containing alkali metal chloride into the anode compartment and an oxygen-containing gas into the cathode compartment.

The present invention provides a process for producing alkali metal chlorate which avoids the problems of using alkali metal chromates associated with previously known processes that employ gas diffusion electrodes and avoids the costs and handling problems associated with using considerable amounts of hydrochloric acid and alkali metal hydroxide that are employed in other known processes, while at the same time provides an energy-efficient electrolytic process for the production of alkali metal chlorate and makes a large portion of externally added pH-adjusting chemicals superfluous.

III. Rejections:

Claims 1-6, 9-11, 23 and 24 stand rejected under 35 U.S.C. § 103(a), as being unpatentable over Millet (US 5,104,499), in view of Oda et al. (US 4,299,682). The Applicants respectfully traverse.

Millet discloses a one-stage electrolysis process for production of alkali metal chlorate (or perchlorate) in the absence of hexavalent chromium values without being coupled to another production. The cathode compartment of the cell contains an aqueous solution of hydroxide in which hydrogen is produced during the production (col.2, l.28-38).

Major objects of Millet involve the following (col.2, l.22-27):

- a) Improved process without presence of deleterious hexavalent chromium values
- b) No requirement for a special electrode
- c) No necessity of separating chloride prior to the desired chlorate
- d) No coupling of production of chlorate with any other production

The anolyte and the catholyte in the respective compartments are uniform, i.e. each is respectively the same in the space which it occupies; the catholyte is uniform due to the agitation provided in the cathode compartment by the release of hydrogen; the constancy and stability of the two electrolytes is assured by continuously and simultaneously introducing chloride in aqueous solution in the anode department and water into the cathode department (col.3, l.31-35, 38-42). In example 1, the agitation of the catholyte (providing for uniformity) by the release of hydrogen was sufficient to insure uniformity (col.4, l.45-47).

In contrast to the statement made in the Office Action, Applicants respectfully submit that they are unaware of any teaching or suggestion by Millet that the solution is transferred to a chlorate reactor. Rather, Millet (at col.2, l.43-45) teaches that "... chlorate produced may be directly separated from the electrolyzed aqueous anolyte by crystallization", i.e. without residing in a chlorate reactor for further reaction of the electrolyzed solution to produce a concentrated alkali metal chlorate electrolyte.

Furthermore, example 1 of Millet discloses that "the electrolysis was continued until the anolyte contained no more than 120 g/l sodium chloride" (col.4, l.56-57).

Hence, it is respectfully submitted that one of ordinary skill in the art would not have any reason (based on Millet) to transfer the electrolyzed solution to a reactor prior to ultimate crystallization.

Furthermore, as acknowledged by the Office Action, Millet is silent on: a) gas diffusion cathode in cathode compartment; and b) step of feeding oxygen-containing gas into the cathode compartment. Further, the Office Action acknowledges that "Of importance is that the reaction at the cathode of Millet produces hydrogen gas and hydroxide ions from the water".

Oda et al teach a gas diffusion electrode which imparts low over voltage, excellent reproducibility, excellent durability, and non-deteriorated catalytic activity (col.1, 1.59-62). The electrode is suitable for electrolysis of alkali metal chloride or as an electrode in an oxidizer side of a fuel cell.

The Office Action contends that it would be obvious to replace the hydrogen-evolving electrode of Millet with the gas diffusion electrode of Oda et al. Applicants respectfully disagree and submit that Millet is not seeking to replace the electrode because there is no requirement for a special electrode as mentioned in Millet at col.2, 1.22-27. Furthermore, necessary agitation and uniformity are provided by the release of hydrogen. Should the hydrogen not be evolved, these conditions would not be fulfilled. For this reason, it is respectfully submitted that Millet teaches that the hydrogen-evolving electrode should not be replaced. As discussed above, the Office Action acknowledges that "of importance is that the reaction at the cathode of Millet produces hydrogen gas...". Applicants respectfully submit that this statement clearly teaches away from replacing the present electrode of Millet.

Moreover, Applicants respectfully take issue with the contention of the Office Action that the "cathode reaction provided by the process cell of Oda et al is identical to the cathode reaction provided by the process of Millet". Although NaOH is formed in both reactions, it is respectfully submitted that the cathodic reactions are different, as follows:

$\text{H}_2\text{O} + 0.5 \text{O}_2 + 2\text{e} \rightarrow 2\text{OH}$ (Oda) including reduction of oxygen at the gas diffusion electrode (col.2, l.32)

$2\text{H}_2\text{O} + 2\text{e} \rightarrow 2\text{OH} + \text{H}_2$ this is the conventional hydrogen gas evolving reaction (Millet)

Furthermore, Applicants respectfully submit that Oda et al are silent on production of chlorate and do not address any of the objects to be achieved in Millet as set out under items a-d above.

Based on the above, it is respectfully submitted that there would be no reason for a person of ordinary skill in the art to combine Millet with Oda et al.

Therefore, it is respectfully requested that the rejections of claims 1-6, 9-11, 23 and 24 over Millet, in view of Oda et al, be withdrawn.

Claims 1, 3-6, 9-11, 24 and 25 stand rejected under 35 U.S.C. § 103(a), as being unpatentable over Millet, in view of Shimamune et al (US 6,117,286). The Applicants respectfully traverse.

Shimamune et al teach an electrolytic cell employing a gas diffusion electrode which enables smooth gas feeding and energy savings for producing sodium hydroxide or hydrogen peroxide by electrolysis. Applicants respectfully submit, however, that they are unaware of any disclosure by Shimamune et al regarding the production of chlorate.

Therefore, for the same reasons discussed above with respect to Millet and the fact that Shimamune et al teach in line with Oda et al applications for gas diffusion electrodes other than chlorate production, replacement of hydrogen-evolving cathode would imply modifications of design and process conditions contrary to the teachings of Millet (e.g., agitation would no longer be provided by hydrogen evolved).

Therefore, it is respectfully requested that the rejections of claims 1, 3-6, 9-11, 24 and 25 over Millet, in view of Shimamune et al, be withdrawn.

Claims 1-5, 7, 9-11 and 23 stand rejected under 35 U.S.C. § 103(a), as being unpatentable over Cook, Jr. (US Pat. No. 3,897,320), in view of Oda et al. (US Pat. No. 4,299,682). The Applicants respectfully traverse.

Cook is directed to the production of chlorates from alkali metal chloride solution in a two compartment cell equipped with an effective cation-active permselective membrane divider with the production of some chlorate in the anolyte and subsequent electrolysis of the anolyte in a chlorate cell (col.1, l.5-13).

Cook states that "an advantage of this invention is that alkali metal chlorate produced by transmission of hydroxide through the membrane into the anolyte is recovered and the anolyte is subsequently utilized as a feed to a chlorate cell (col.1, l.19-23). It is further set out that "because the cation-active permselective membrane 23 allows some hydroxyl ions to migrate through it from the catholyte to the anolyte these can react to produce chlorate in the anolyte" (col.2, l.10-12). Cook further teaches that the cation-active permselective membrane should permit from 5 to 50 percent of the caustic produced in the catholyte compartment to migrate to the anolyte compartment (col.7. l.10-13).

Applicants submit that the presently claimed invention differs from Cook, as acknowledged by the Office Action, by defining the use of a gas diffusion electrode and introduction of oxygen-containing gas in the cathode compartment of the electrolytic cell.

It is submitted that the present invention is further distinguished from Cook by defining that the electrolyzed solution from the anode compartment is transferred to a chlorate reactor to further produce a concentrated chlorate electrolyte.

In contrast, Applicants submit that Cook teaches transferring the electrolyzed solution to a conventional non-divided chlorate cell electrolyzer rather than to a reactor. In such an undivided cell, further chlorate is formed in a common compartment.

Cook being silent on gas diffusion electrode-equipped cells and transfer of electrolyzed solution to a reactor, it would not be obvious for a person of ordinary skill in the art to arrive at the presently claimed invention.

As discussed above with respect to Oda et al, Applicants respectfully submit that it would not be obvious to replace the existing hydrogen-evolving cathode of Cook with a gas diffusion electrode of Oda et al since Oda et al is silent on chlorate production and that there is no reason based on Cook for a skilled person to modify any of the cathodes used in the chlorine and chlorate cells.

Regarding the contention of the Office Action that "...the membrane of Oda et al would have permitted a small amount of the hydroxide ions to cross, similarly to Cook, Jr.,...", Applicants respectfully submit that even if chlorate could be formed to some extent in the anolyte, this small quantity would be insignificant compared to the present invention and would not be recognized by one of ordinary skill in the art without hindsight of the present application.

Therefore, it is respectfully requested that the rejections of claims 1-5, 7, 9-11 and 23 under 35 U.S.C. § 103(a), as being obvious over Cook, in view of Oda et al, be withdrawn.

Claims 1-6, 8, 10-12 and 23 stand rejected under 35 U.S.C. § 103(a), as being unpatentable over Wanngard (US 5,419,818), with evidence from Cook, and in view of Oda et al. The Applicants respectfully traverse.

Wanngard is directed to a process of producing alkali metal chlorate in an energy-efficient manner involving significantly reduced health and environmental hazards making superfluous a large portion of the chemicals added in processes for

acidification and alkalization. However, Applicants submit that they are unaware of any disclosure by Wanngard of a cell equipped with a separator that is used to produce the chlorate, as presently claimed. To the contrary, Applicants respectfully submit that Wanngard teaches that the chlorate is produced using a non-divided cell and separate chlorate reactor.

Wanngard teaches "an ion-selective membrane" such as a cation selective membrane as set out in col.5, l.4-6 and not a cation-active permselective membrane. Applicants respectfully submit that there are at least no explicit teachings with respect to the selection of separator in Wanngard indicating that hydroxide ions would be able cross the separator so as to cause formation of chlorate ions in the anolyte compartment.

Applicants respectfully submit that Wanngard relates to an integrated process involving a conventional hydrogen-evolving cathode. Wanngard further solves the problem of reducing chemicals added in the conventional processes for acidification and alkalization (col.2, l.50-52). The electrolysis in the cell equipped with a separator yields an anolyte and a catholyte having lower and higher pH respectively than the chlorate electrolyte supplied to the separator-equipped cell (col.2, l.67-col.3, l.2).

Consequently, a skilled person would have no reason to modify the teaching of Wanngard in such a way that the instant process is arrived at since Wanngard is not aiming at providing a divided chlorate cell, particularly not a divided chlorate cell equipped with a gas diffusion electrode. Rather, Wanngard focuses on providing an integrated production of acid and alkali metal hydroxide in a conventional undivided cell but by using a portion of the chlorate electrolyte for production of acid anolyte and alkali metal hydroxide in the catholyte of a divided chloralkali cell. It is respectfully submitted that a skilled person could thus not foresee that a divided chlorate cell would advantageously contribute to produce integrally acid and alkali metal hydroxide. On the contrary, since several parameters differ between divided and undivided chlorate cells including e.g. mixing conditions of electrolyte, control of pH, need of supplying acid/hydroxide, the skilled person would not search for the solution in technology

describing divided chlorate cells, particularly not Oda et al, which is silent on integrated production of acid and alkali metal hydroxide and production of chlorate nor Cook which transfers the anolyte to a further electrolyzing cell.

Moreover, Wanngard teaches that both the anode and cathode compartments, of the cell containing a separator (12), are charged with chlorate electrolyte containing significant amounts of chlorate (see col. 6, l.31-34). If such a divided cell included a gas diffusion electrode according to Oda et al in the cathode chamber, the chlorate ions in the cathode chamber would result in side reactions that would lead to poisoning of the gas diffusion electrode and make it inoperable. See, for example, the discussion in the instant specification at p.1, l.26-33.

Therefore, it is respectfully requested that the rejections of claims 1-12 and 23 under 35 U.S.C. § 103(a), as being obvious over Wanngard, as purportedly evidenced by Cook, in view of Oda et al., be withdrawn.

Conclusion:

In light of the foregoing, Applicants respectfully submit that the application as amended is now in proper form for allowance, which action is earnestly solicited. If the Examiner has any questions relating to this Amendment or to this application in general, it is respectfully requested that the Examiner contact Applicants' undersigned attorney at the telephone number provided below.

Respectfully submitted,



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